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(54) **BLOCK MOUNTED OVERHEAD CAM SUPPORT SYSTEM FOR INTERNAL COMBUSTION ENGINES**

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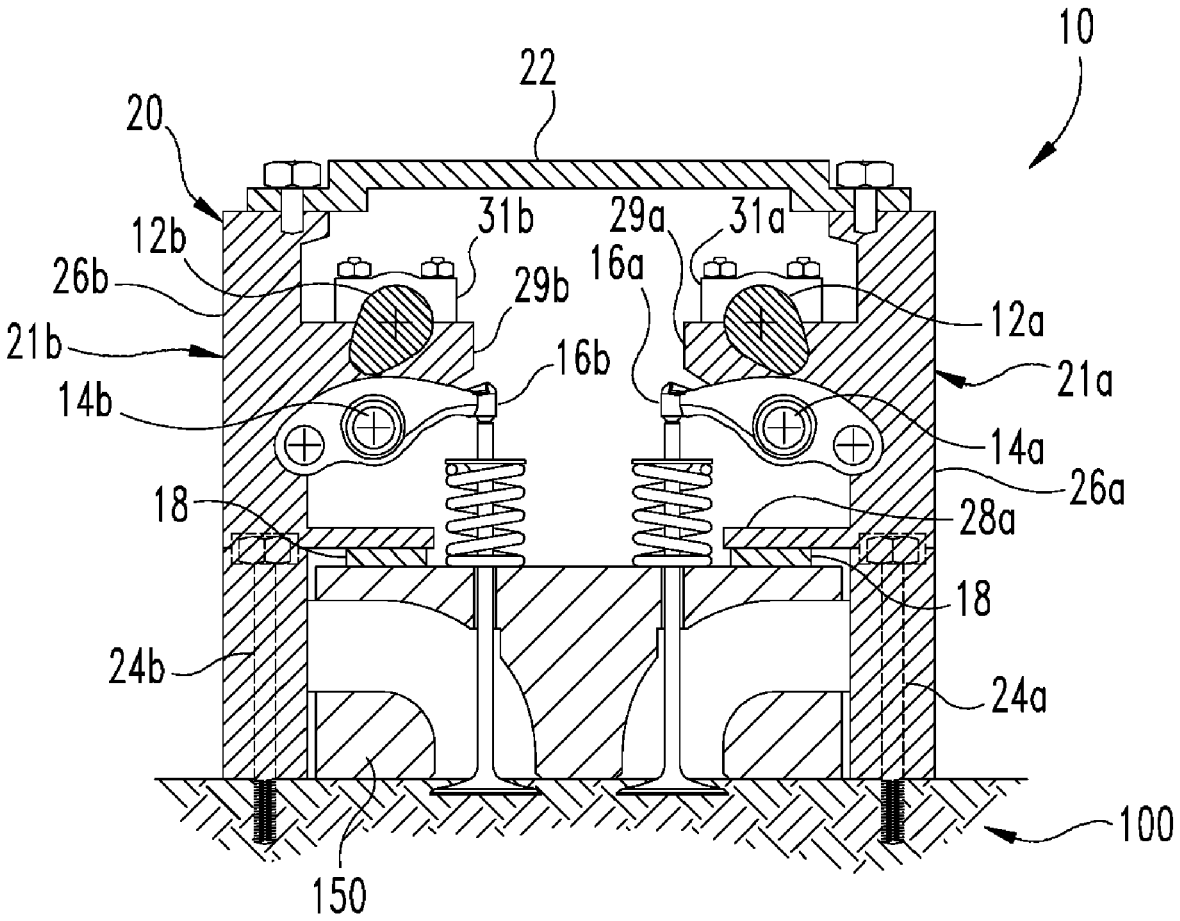
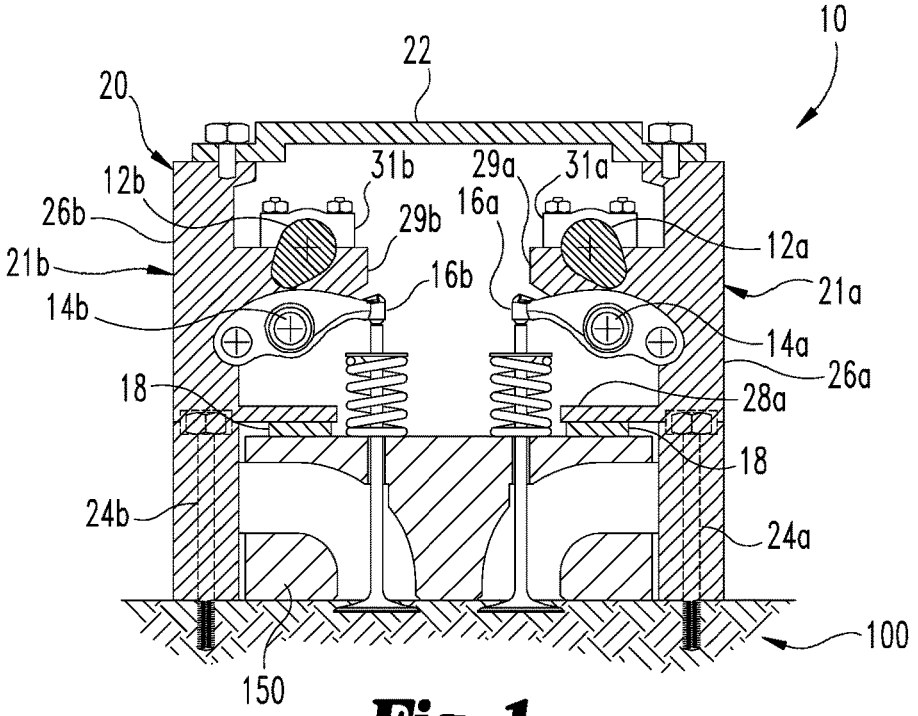
(57) **ABSTRACT**

Systems, devices, and methods are disclosed for supporting one or more camshafts by the engine block in overhead arrangement relative to the cylinder heads and valve train.

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22
20
12b
31b
29a
31a
26b
29b
16a
12a
21b
16b
21a
14b
14a
26a
18
28a
18
24b
24a
100
150

Fig. 1

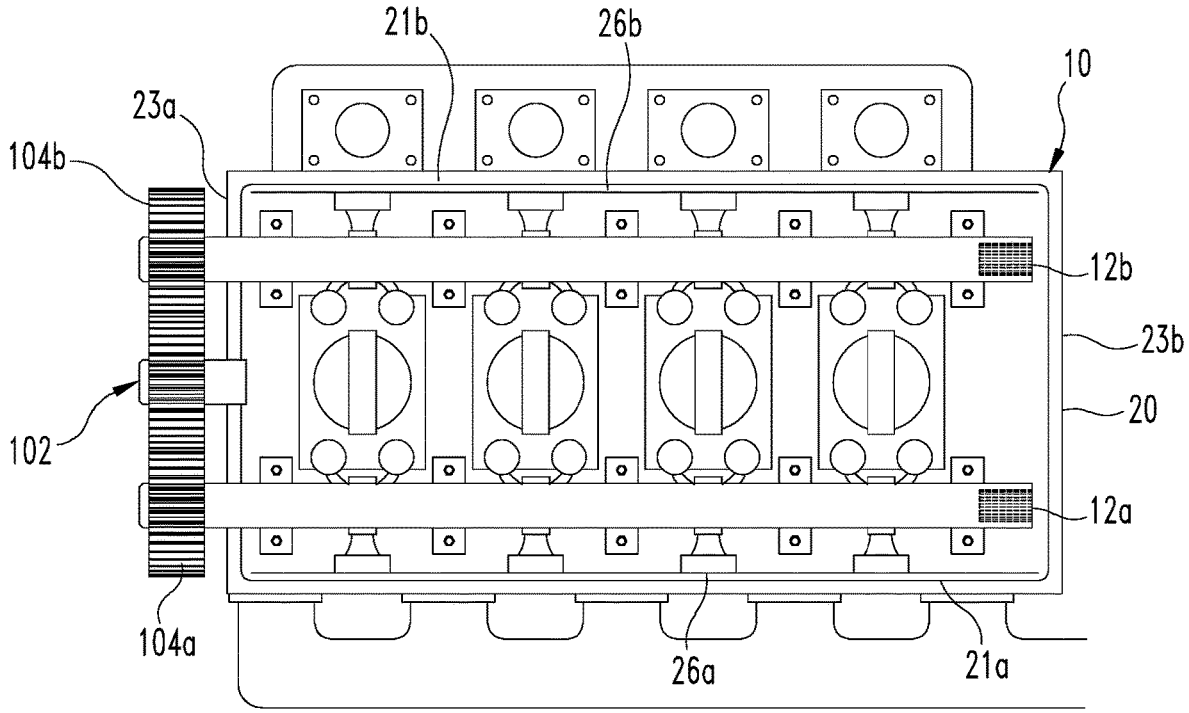
21b
26b
10
23a
104b
12b
23b
102
20
12a
104a
26a
21a

Fig. 2

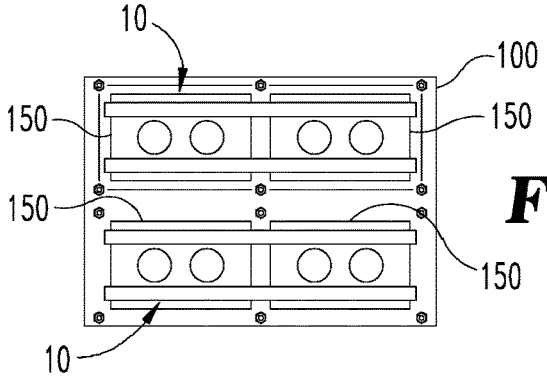

Fig. 3A

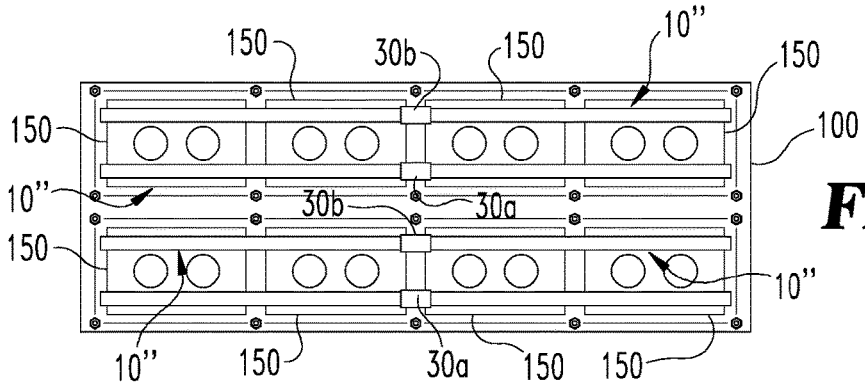

Fig. 3B

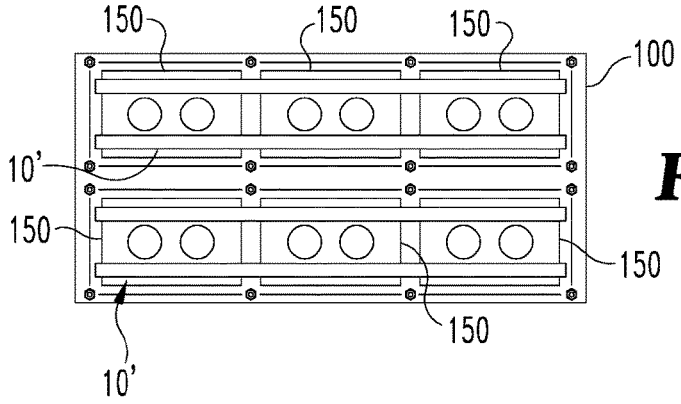

Fig. 3C

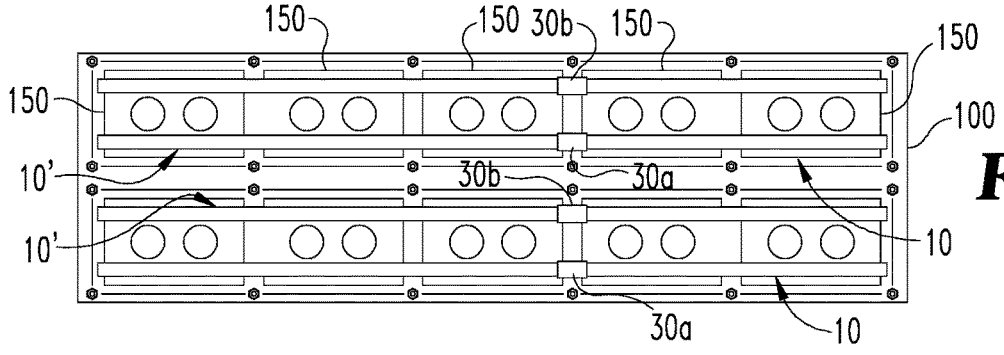

Fig. 3D

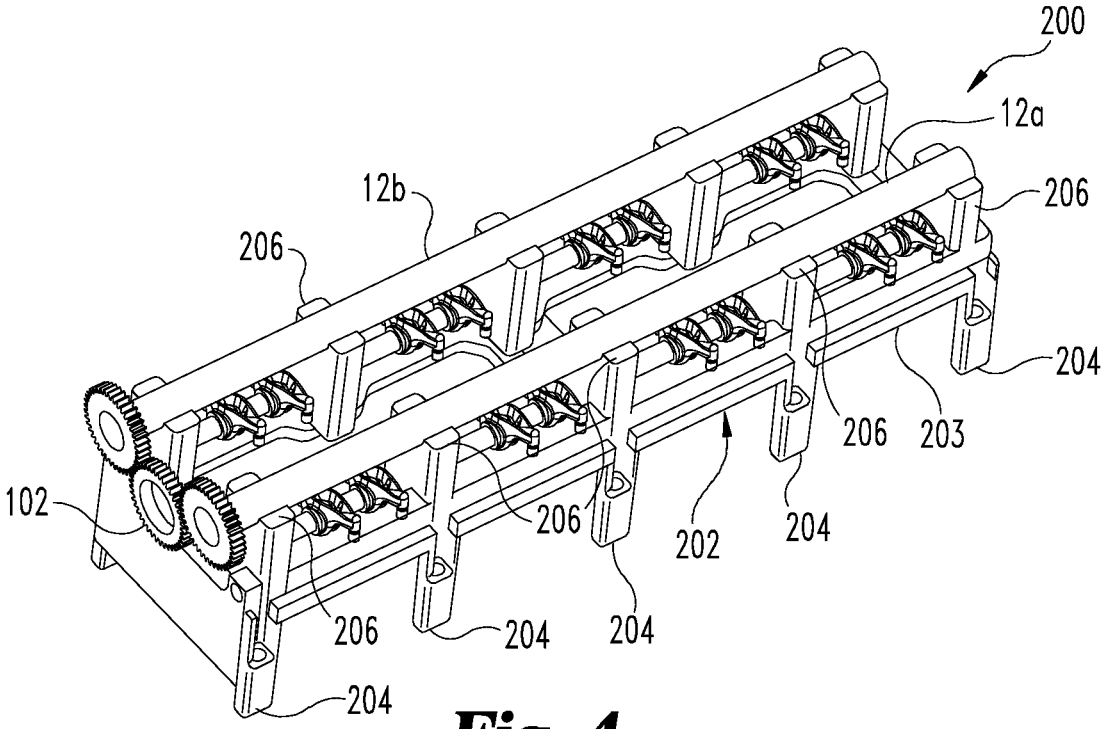
200
12a
12b
206
206
204
206
203
102
206
202
204
206
204
204
204

Fig. 4

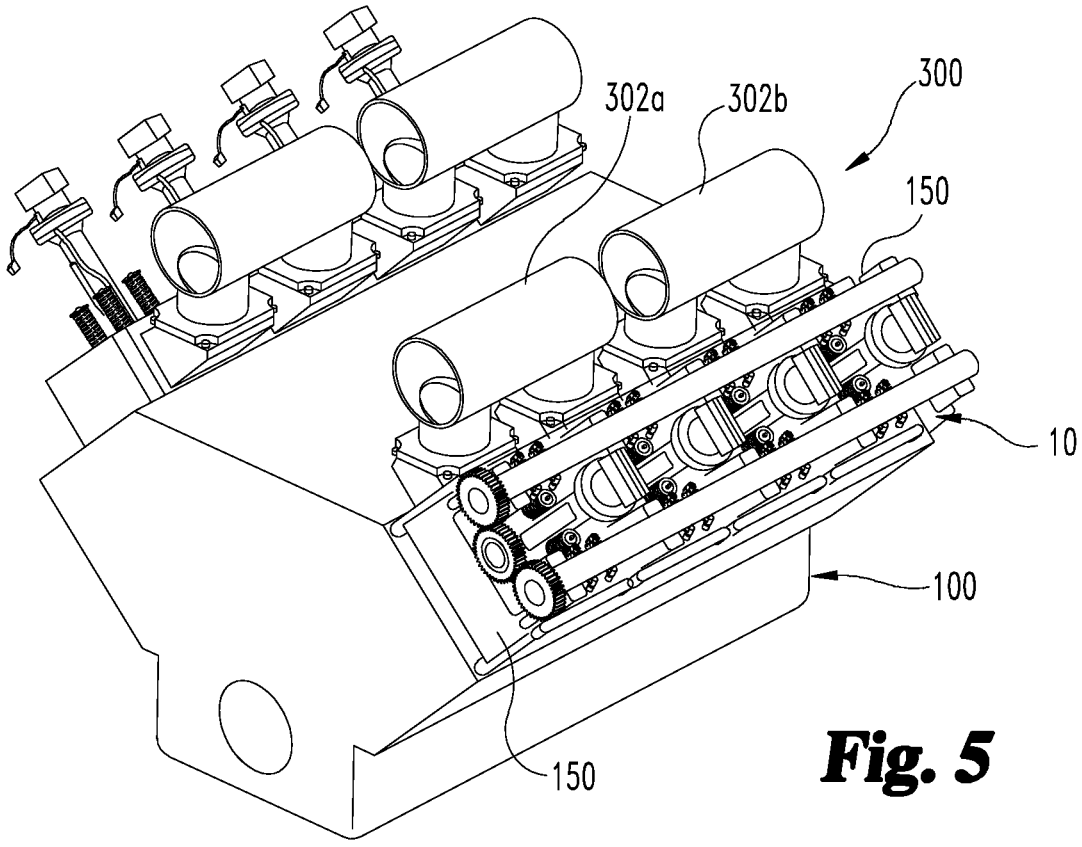
300
302a
302b
150
10
100
150

Fig. 5

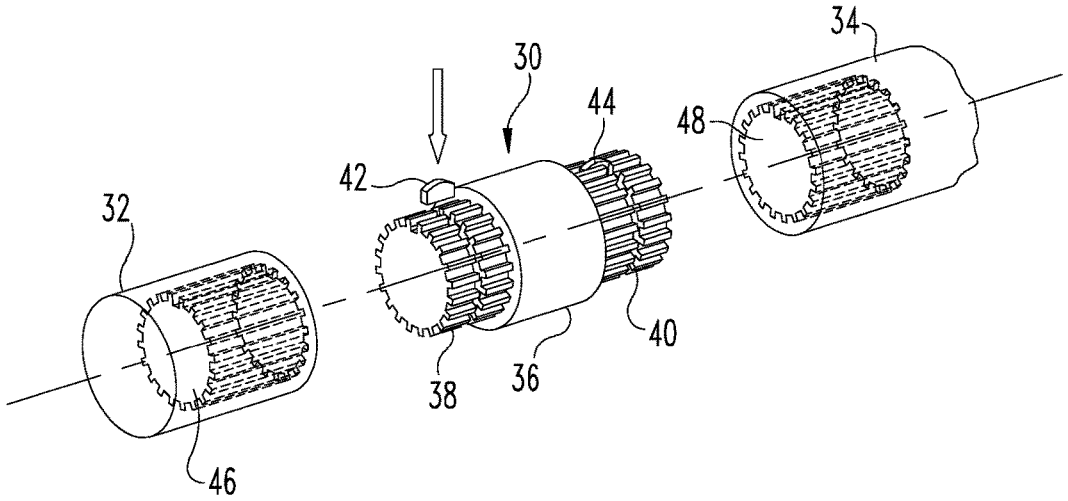

Fig. 6

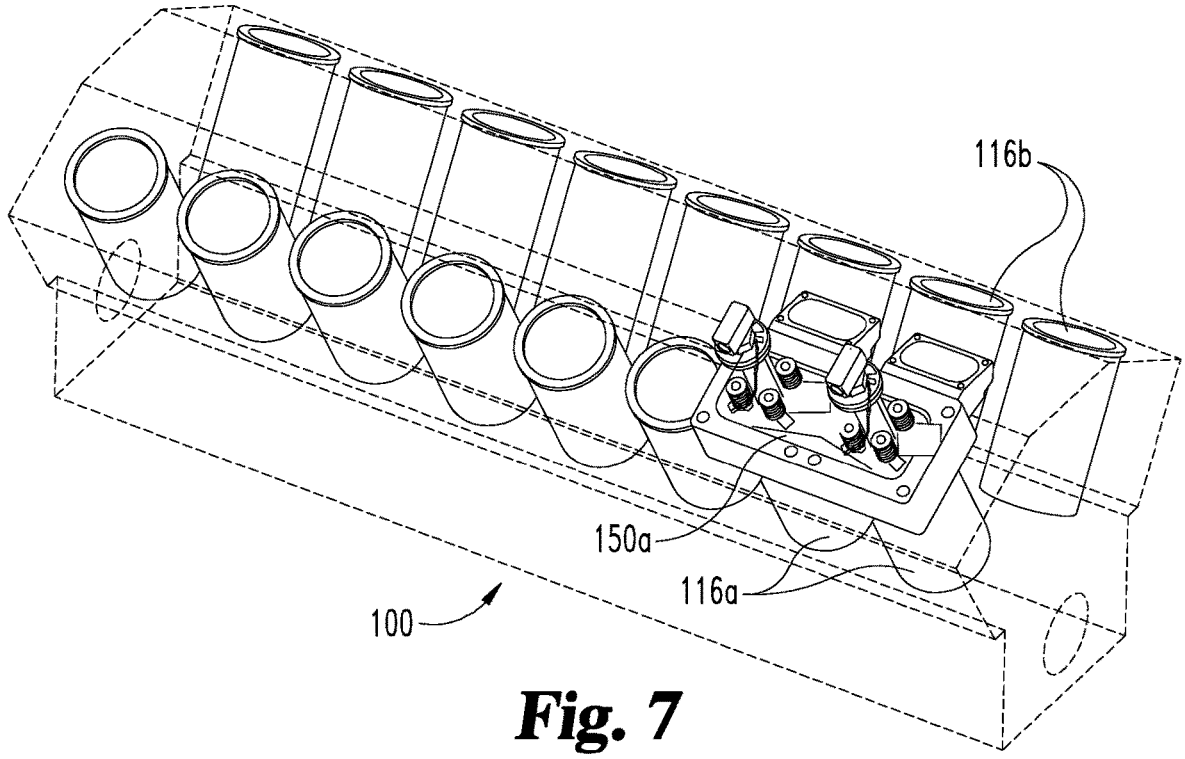

Fig. 7

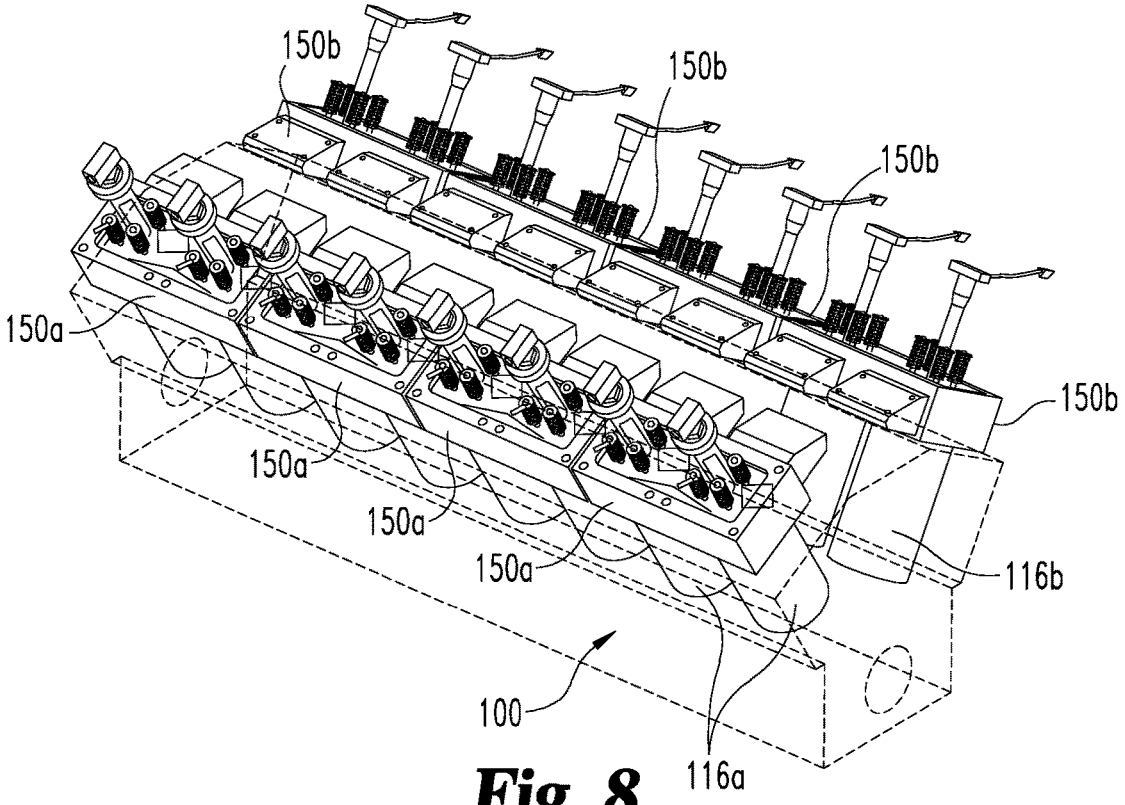
150b
150b
150b
150a
150b
150a
150a
150a
116b
100
116a

Fig. 8

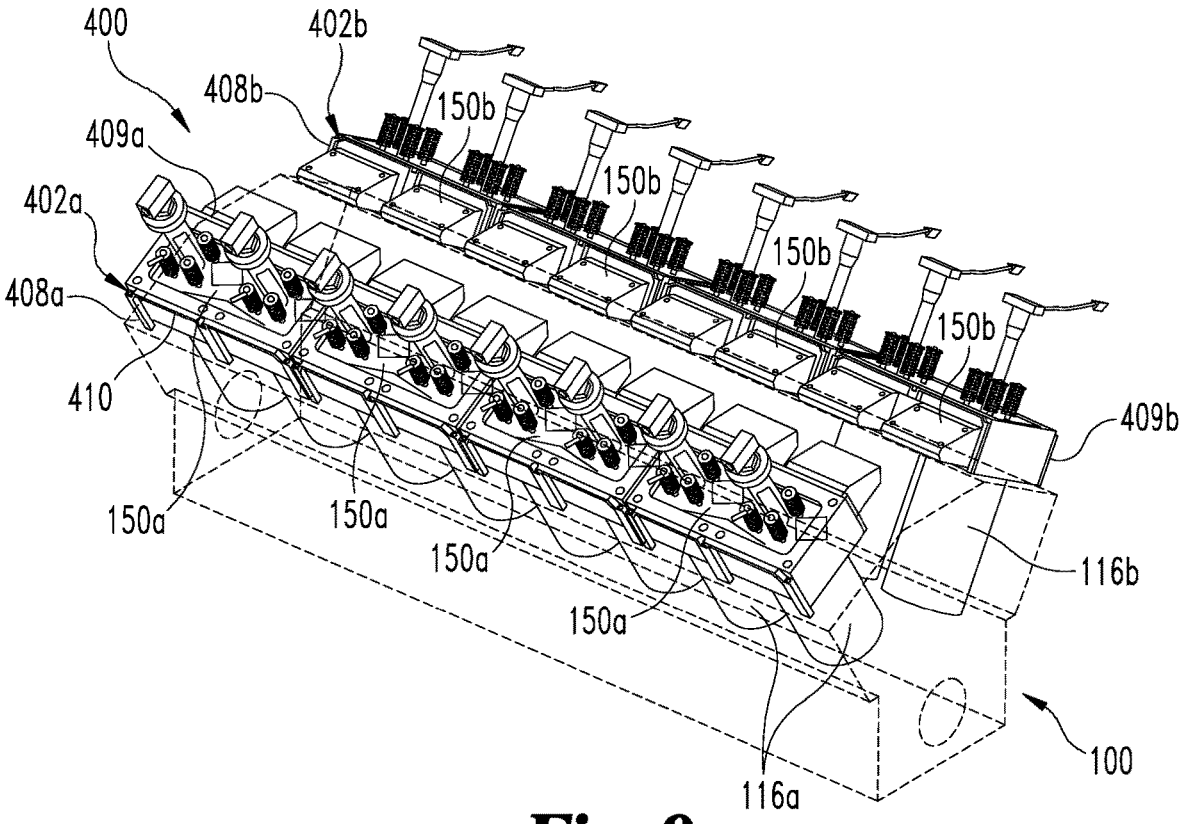
400
402b
408b
150b
409a
150b
402a
150b
150b
408a
410
409b
150a
150a
150a
116b
150a
100
116a

Fig. 9

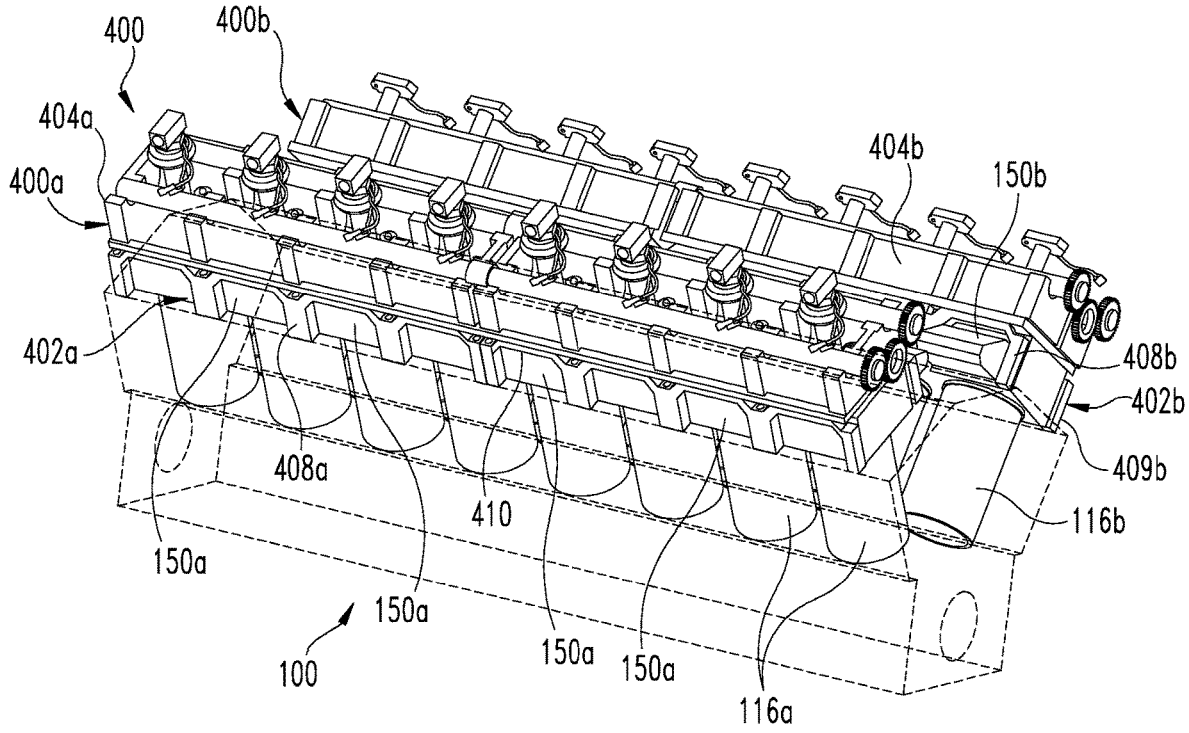
400
400b
404a
400a
404b
150b
402a
408b
402b
409b
408a
410
116b
150a
150a
150a
150a
100
116a

Fig.10

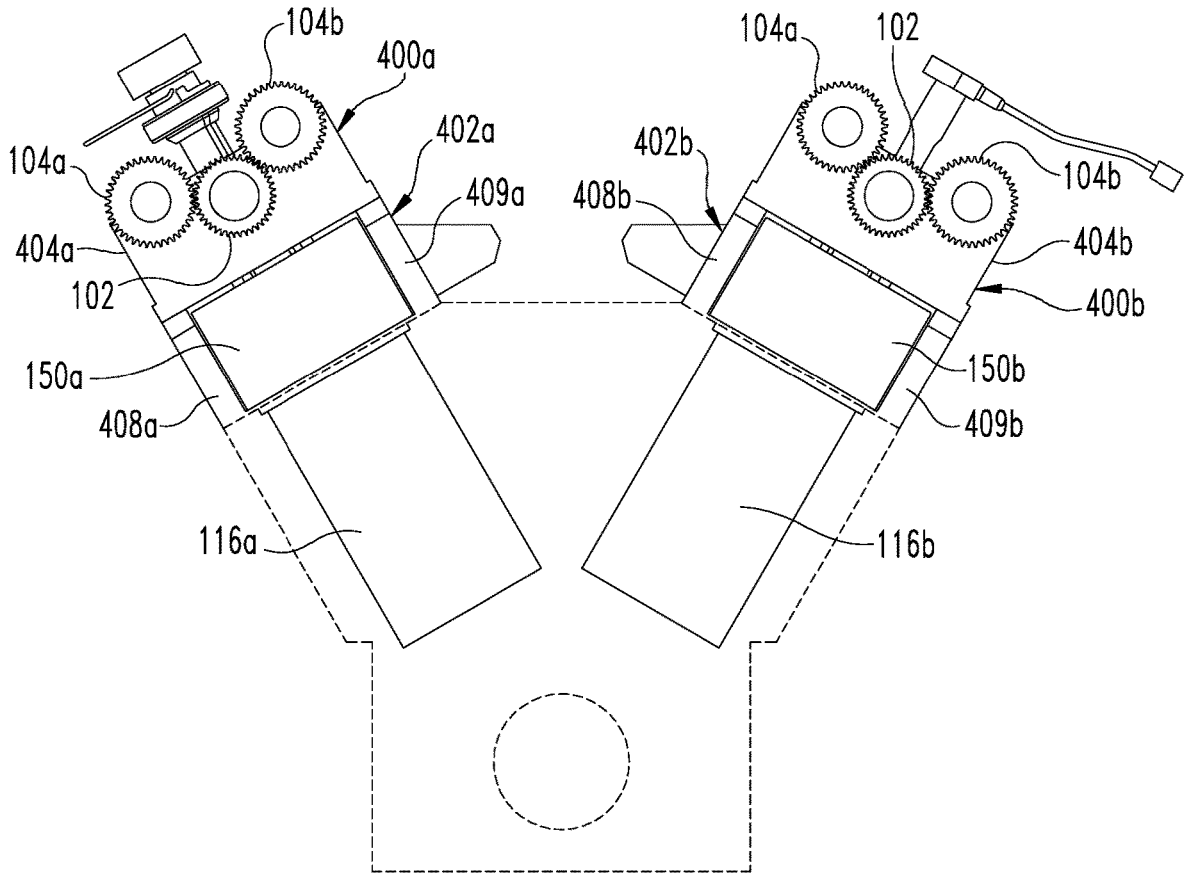
104b
400a
402a
104a
409a
404a
102
150a
408a
116a
104a
102
402b
408b
104b
404b
400b
150b
409b
116b

Fig. 11

BLOCK MOUNTED OVERHEAD CAM SUPPORT SYSTEM FOR INTERNAL COMBUSTION ENGINES

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is a continuation of PCT Application No. PCT/US18/22580, filed Mar. 15, 2018, which claims the benefit of the filing date of US Provisional Application Ser. No. 62/472,273 filed on Mar. 16, 2017, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to internal combustion engines, and more particularly to systems, devices and methods for a modular overhead cam support system that is mounted to a cylinder block of the internal combustion engine independently of the cylinder head.

BACKGROUND

[0003] Large diesel and natural gas engines typically employ cam-in-block arrangements utilizing a push rod driven valve train. Cam-in-block designs can lead to a reduction in strength and stiffness in the cylinder block, additional mass, and service challenges. Cam-in-block designs also incur additional valve train inertia and other losses, and impose limitations on the block and cylinder head design.

[0004] By moving the camshaft out of the block and into an overhead position, various different valve train arrangements can be implemented. However, adding the camshaft above the cylinder head has led to restrictions in the serviceability of individual cylinders. Also, long multi-cylinder slab heads are not favorable due to their serviceability and manufacturing complexity. In addition, placing the valve train on top of a slab cylinder head significantly increases the total assembly mass and complexity of the slab head system, negatively impacting the serviceability and repair time for the customer.

[0005] As desired cylinder operating pressures increase and more complex valve train arrangements are required for new engine designs, it would be desirable to have flexibility in the engine hardware to be integrated into those designs and be able to share common parts across engine families. Cam phasing, cam timing, cylinder deactivation, cam switching, cam duration, variable valve lift, and cam-less technology will become a significant enabler for engine manufacturers to allow additional optimization and improvement in engine efficiency and emissions reduction. Therefore, further improvements in this technology area are needed to address these issues, among others.

SUMMARY

[0006] One embodiment of the present disclosure includes a unique system, method and/or apparatus for a modular overhead cam support system that can be applied to inline and V-type internal combustion engines, where the cam support system is mounted to the engine independently of the cylinder head. The overhead cam support system can be configured for single, twin and other cam or cam-less configurations including cam-in-cam arrangements.

[0007] The overhead cam support system in the present disclosure enables the use of a shorter (1, 2, 3 or 4 cylinder) cylinder head while also providing the potential for various overhead valve train and camshaft configurations. The overhead cam support system also enables the use of variable valve actuation (VVA) technology for complex markets including cam phasing of intake and exhaust events as well as variable valve lift and duration. The overhead cam support system can enable the engine architecture to be easily adapted to provide a de-tiered or simple overhead cam arrangement for cost-sensitive less regulated markets.

[0008] The overhead cam support system provides modularity and flexibility that enables tailoring of an engine family for different fuel variants while retaining the same base engine architecture and thus reducing the number of new, fuel specific components needed. The overhead cam support system allows for different heads to be interchanged independently of the overhead arrangement, allowing an increase in option flexibility, an increase in part commonality and a reduction in development cost.

[0009] The overhead cam support system improves the serviceability of the cylinder head assembly on large, multi-cylinder engines by enabling the use of shorter cylinder heads that span fewer cylinders (1 or 2 or 3 or 4 cylinders at a time). Shorter cylinder heads reduce the mass of the serviceable item and help enable the manual handling of the cylinder heads in the field. This is a significant advantage over longer, heavier slab cylinder heads, such as those used in space constrained environments such as marine, mining and mobile power generation engines due to the limited engine bay space. In addition, repair times are reduced and the modularity provides cost reduction due to the applicability of the overhead cam support system to multiple engine platforms.

[0010] The overhead cam support system is also scalable and can enable the use of two cam carrier housings per cylinder bank for dual overhead cam designs. This embodiment can utilize multiple sections of camshaft that are coupled together to span more than one cylinder head assembly. In certain embodiments, two sections of camshaft are used per cylinder bank, but the use of more than two cam sections per cylinder bank is also possible. The coupling between the camshafts can be configured so that one section of the cam carrier housing can be removed without requiring the removal of a neighboring section. The overhead cam support system also includes the option to retain the camshaft assembly and follower assembly to the cam carrier housing when removing for service and assembly. This helps to ensure cam timing and phasing is maintained during routine maintenance and enables the manufacturing facility to sub-assemble the system.

[0011] In further embodiments, the overhead cam support system can provide lash adjustment through the use of hydraulic tappets that reduce the need for routine lash maintenance. The overhead cam support system can also provide independent interchangeability of the head assembly to the valve train. Furthermore, the overhead cam support system allows the cylinder head to flex without transferring any loads into the valve train/camshaft assembly, such as may occur in response to intake manifold overpressure (IMOP) events, since the overhead cam support system is mounted to the engine block independently of the cylinder head. The overhead cam support system also provides scalable overhead cam arrangements that work with multiple cylinder head engine arrangements.

[0012] This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Further embodiments, forms, objects, features, advantages, aspects, and benefits shall become apparent from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The description herein makes reference to the accompanying drawings wherein like numerals refer to like parts throughout the several views, and wherein:

[0014] FIG. **1** is a cross-sectional view of a dual overhead cam support system mounted to the engine block.

[0015] FIG. **2** is a plan view of the dual overhead cam support system of FIG. **1**.

[0016] FIG. **3**A-**3**D show various dual overhead cam support system arrangements and engine configurations.

[0017] FIG. **4** is a perspective view of another embodiment dual overhead cam support system which would be mounted to the engine block.

[0018] FIG. **5** is a perspective view of an engine block with an inboard exhaust system and a dual overhead cam support system mounted to the engine block.

[0019] FIG. **6** is an exploded perspective view of one embodiment of a coupling arrangement between camshaft sections.

[0020] FIG. **7** is a perspective view of a single two cylinder head of a V-16 engine embodiment.

[0021] FIG. **8** is the engine of FIG. **7** with multiple two cylinder heads arranged on the cylinders of the engine block.

[0022] FIG. **9** is the engine of FIG. **7** with support legs of the dual overhead cam support system mounted to the engine block.

[0023] FIG. **10** is the engine of FIG. **9** with the cam carriers mounted to the support legs and drive couplings engaged to the cams.

[0024] FIG. **11** is an end view of the engine and cam support system of FIG. **10**.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0025] For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, any alterations and further modifications in the illustrated embodiments, and any further applications of the principles of the invention as illustrated therein as would normally occur to one skilled in the art to which the invention relates are contemplated herein.

[0026] FIGS. **1** and **2** show a cross-section view and a plan view, respectively, of a modular dual overhead cam support system according to one embodiment of the present disclosure. It should be understood the cam support system disclosed herein can be employed on other overhead cam arrangements that are not dual overhead camshafts, as discussed above. Cam support system **10** is independently supported on the cylinder block **100** of the engine and not on or by the cylinder head **150**. Cam support system **10** allows the cylinder head **150** to flex without transferring any loads into the valve train/camshaft assembly supported by cam support system **10**. Cam support system **10** provides scalable overhead cam support arrangements that work with multiple cylinder head types of engines.

[0027] FIG. **1** shows two overhead camshafts **12***a*, **12***b* that are each engaged with a respective one of the roller follower valve trains **14***a*, **14***b* with hydraulic lash adjusters **16***a*, **16***b*. Adjusters **16***a*, **16***b* can each include or be connected to an intake valve or an exhaust valve and an associated valve spring. Each intake or exhaust valve is connected to a hydraulic tappet that is connected with a respective roller follower that pivots around a follower pivot. The overhead cam support system **10** is mounted, independently of the cylinder head **150**, directly to the engine block **100** and sits above the cylinder head **150**. A sealed interface between the head **150** and cam support system **10** is provided by seal **18** (such as an elastomer seal) which keeps oil inside the rocker housing and dirt out.

[0028] Cam support system **10** includes a carrier housing **20** to support camshafts **12***a*, **12***b* that in the illustrated embodiment of FIGS. **1**-**2** is a single or unitary piece. Carrier housing **20** could also be arranged in two pieces to improve assembly and disassembly while in service. Carrier housing **20** includes a first leg **21***a* along one side of cylinder head **150** and a second leg **21***b* along a second, opposite side of cylinder head **150**. A valve cover **22** can be engaged to the upper end of the cam carrier **29***a*, **29***b* of carrier housing **20** which is supported on the carrier legs **21***a*, **21***b*. Carrier bolts **24***a*, **24***b* can be provided that extend through bores in carrier housing **20** or alternatively through the carrier legs **21***a*, **21***b* to engage block **100**. In the illustrated embodiment, carrier housing **20** includes a vertically extending wall portion **23***a*, **23***b*, **26***a*, **26***b* that includes a lower end sitting on block **100** and an opposite upper end engaged to valve cover **22**. Each wall portion **23***a*, **23***b*, **26***a*, **26***b* includes inwardly extending flange **28***a*, **28***b* to provide engagement with seal **18** against head **150**. Each wall portion **26** includes a cam support arm **29***a*, **29***b* that supports respectively one of the camshafts **12***a*, **12***b* thereon. A camshaft retaining cap **31***a*, **31***b* can be engaged to respective ones of support arm **29***a*, **29***b* around the correspondingly supported camshaft **12***a*, **12***b*. Carrier housing **20** may also include one or more support structures for rocker pivots, seals for cam-to-cam drive couplings, a cam/rocker cover, and suitable sealing arrangements to prevent the egress of fluids. Carrier housing **20** may also house hydraulic lash adjusters, tappets, and parts of the lubrication circuit for the cam, follower, and hydraulic lash adjusters.

[0029] FIG. **2** shows a plan view of the overhead cam support system **10** in a V-8 configuration. Carrier housing **20** includes end walls **23***a*, **23***b* connecting legs **21***a*, **21***b* to provide a rectangular-shaped carrier housing. In another embodiment, the lower portions of the end walls **23***a*, **23***b* can be omitted so legs **21***a*, **21***b* are not directly connected to one another. A common cam drive gear **102** connected to the crank shaft is provided on carrier housing **20** in the center between camshafts **12***a*, **12***b* and two cam gears **104***a*, **104***b*, One drive gear **102** and cam gears **104***a*, **104***b* can be provided for each of the left cylinder bank and the right cylinder bank. For variable valve timing (VVT) or VVA arrangements, the cam gears **104***a*, **104***b* can be interchanged for cam phasers. It is further contemplated that an electric drive, chain, or belt can drive the camshafts **12***a*, **12***b*.

[0030] FIGS. **3**A-**3**D show the principle of using multiples of a two cylinder head **150** to cover pairs of engine cylinders

including a V-8 in FIG. **3**A, a V-16 in FIG. **3**B, a V-12 in FIG. **3**C, and a V-20 in FIG. **3**D. Other engine sizes and cylinder numbers are also contemplated other than those shown. Also shown are cam support systems **10** that span heads that cover two cylinder pairs such as shown in FIG. **3**A, and also a cam support system **10'** sized to span three cylinder pairs as shown in FIG. **3**C, a cam support system **10"** sized to extend over four cylinder pairs as shown in FIG. **3**B. Combinations of these are also contemplated as shown in FIG. **3**D. FIGS. **3**B and **3**D also show couplings **30***a*, **30***b* (also collectively or individually referred to as coupling **30**) to connect two sections of respective ones of the camshafts **12***a*, **12***b* together. In one embodiment of the V-12 engine shown in FIG. **3**C, a first camshaft section can be provided that is sized to extend along two cylinder pairs and a second camshaft section is provided to extend along one cylinder pair on each side of the cylinder bank, and the first camshaft section is connected in end-to-end fashion with the second camshaft section. In still another embodiment, a unit head engine is provided with a single head per cylinder. For a V-12 engine, each of the camshaft sections can be connected in end-to-end fashion and are each sized to extend along three cylinders.

[0031] FIG. **4** shows one bank of another embodiment overhead cam support system **200** for a V-8 configuration engine with double overhead valvetrain. Cam support system **200** incorporates a single piece cam carrier housing **202** with mounting legs **204** that extend downwardly from the center wall section **203** of housing **202** for engagement with the engine block **100**. Each of the legs **204** includes a bore to receive an elongated bolt or other fastener for connection of carrier housing **202** to the engine block. The central drive gear **102** is mounted to the carrier housing **202** to allow the assembly to be removed in one piece and with the timing locked in place. Carrier housing **202** also includes cam support arms **206** that extend upwardly from center wall section **203** and inwardly toward one another to support camshafts **12***a*, **12***b* relative to the cylinder heads.

[0032] FIG. **5** shows one embodiment of an inboard exhaust system **300** using multiple sections **302***a*, **302***b* that could be joined together with a flexible connection, such as a bellows or sliding piston type joint. Each section **302***a*, **302***b* sits on a common mounting face of a respective cylinder head **150** to help to reduce assembly variation and tolerance stack up. The exhaust system **300** arranged in this example can use a log manifold, and the extra material in the cylinder head **150** for supporting the respective exhaust manifold section can also include internally a pulse converter to reduce the effect of cylinder back filling, thus improving engine scavaging capability and reducing in-cylinder residuals.

[0033] FIG. **6** shows one embodiment of a camshaft coupling **30**. The camshaft coupling **30** can connect two camshaft sections **32**, **34** to one another in end-to-end fashion. In one embodiment, coupling **30** includes a center hub **36** with splined sections **38**, **40** extending axially in opposite directions from center hub **36**. In addition, each splined section includes a key **42**, **44** projecting radially outwardly therefrom. Camshaft sections **32**, **34** each include a longitudinal bore **46**, **48** with a corresponding keyway that receives respective ones of the splined sections **38**, **40** and its associated key **42**, **44** in the keyway. In certain embodiments, splined sections **38**, **40** include other configurations, such as a D-shaped or other shape that is received in a correspondingly complementary non-circular shaped longitudinal bore **46**, **48**. The camshaft coupling **30** can be used to connect camshaft sections in engines that, for example, have more than 8 cylinders.

[0034] FIGS. **7-11** show another embodiment overhead cam support system **400** in which the carrier housing is comprised of multiple sections. In FIG. **7** an engine block **100** is shown with sixteen cylinders **116** and one pair of the cylinders **116***a* of a first cylinder bank is covered by a first cylinder head **150**. FIG. **8** shows the same block **100** with cylinders **116***a* in the first cylinder bank and cylinders **116***b* in a second cylinder bank, and with eight cylinder heads **150***a*, **150***b* over respective pairs of the cylinders **116***a*, **116***b*.

[0035] In FIG. **9** cam support system **400** includes a lower carrier housing section **402***a* with legs **408***a*, **409***a* (see also FIG. **11**) along the opposite sides of cylinder heads **150***a* and the valve train of the first cylinder bank, and a second lower carrier housing section **402***b* with legs **408***b*, **409***b* along the opposite sides of cylinder heads **150***b* and the valve train of the second cylinder bank. Legs **408***a*, **409***a* and legs **408***b*, **409***b* are provided at each end of each cylinder head **150***a*, **150***b* and between adjacent ones of the cylinder heads **150***a*, **150***b*. The legs **408***a*, **409***a*, **408***b*, **409***b* on each side of the cylinder heads **150***a*, **150***b* are connected by a flange **410**, and a plurality of bores are provided in legs **408***a*, **408***b*, **409***a*, **409***b* and flanges **410** to receive bolts to secure the lower section to block **100**.

[0036] FIGS. **10** and **11** show the overhead cam support system **400** with upper sections **404***a*, **404***b* mounted the respective lower sections **402***a*, **402***b*. In the illustrated embodiment, each upper section **404***a*, **404***b* includes two parts that each span two cylinder pairs **150***a*, **150***b*. The upper sections **404***a*, **404***b* each have a rectangular shape with opposite sidewalls and endwalls connecting the opposite sidewalls, and the idler gear **102** connected to one of the endwalls of each upper section **404***a*, **404***b*. This embodiment reduces machining complexity of the cam support system **400**, and improves serviceability, especially in applications where the front or rear of the engine is constrained and access restricted.

[0037] Various aspects of the present disclosure are contemplated. According to one aspect, an overhead cam support system includes a carrier housing with a lower end positionable on an engine block independently of a cylinder head of the engine. The carrier housing rotatably supports at least one camshaft on the engine block for engagement with at least one valve of the cylinder head.

[0038] In one embodiment, the system includes a valve cover engaged to an upper end of the carrier housing that is opposite the lower end of the carrier housing. In one refinement of this embodiment, the carrier housing includes a flange extending over an upper surface of the cylinder head, and a seal is provided between the flange and an upper surface of the cylinder head. In another refinement, the carrier housing includes at least one cam support arm extending outwardly therefrom adjacent the upper end of the carrier housing, and the camshaft is supported on the at least one cam support arm. In a further refinement, the system includes a camshaft retaining cap engaged to the cam support arm and the camshaft retaining cap extends around the at least one camshaft.

[0039] In another embodiment, the at least one camshaft includes first and second camshafts including respective ones of first and second cam gears or phasers that are

engaged to an idler gear mounted to the carrier housing. In yet another embodiment, the carrier housing includes first legs and second legs extending on opposite sides of the cylinder head and a first flange and a second flange extending along opposite sides of the cylinder head connecting the first legs and the second legs, respectively. In still another embodiment, the engine block includes at least eight cylinders and each cylinder head extends over two cylinders.

[0040] In another embodiment the at least one camshaft includes at least two camshaft sections connected to one another in an end-to-end manner. In a refinement of this embodiment, the system includes a camshaft coupling that includes a center hub with splined sections extending axially in opposite directions from the center hub, and each camshaft section includes a longitudinal bore configured to receive respective ones of the splined sections. In a further refinement, each splined section includes a key projecting radially outwardly therefrom that is received in a keyway along the longitudinal bore of the respective cam section. In another further refinement, each splined section includes a non-circular cross-section that is received in a complementary shaped one of the longitudinal bores.

[0041] In yet another refinement, a first camshaft section is sized to extend along three cylinder pairs and a second camshaft section is sized to extend along two cylinder pairs, and the first and second camshaft sections are connected in end-to-end relation. In still another refinement, a first camshaft section is sized to extend along two cylinder pairs and a second camshaft section is sized to extend along two cylinder pairs, and the first and second camshaft sections are connected in end-to-end relation. In another embodiment, a first camshaft section is sized to extend along two cylinder pairs and a second camshaft section is sized to extend along one cylinder pair, and the first and second camshaft sections are connected in end-to-end relation. In yet another embodiment, a first camshaft section is sized to extend along three cylinders and a second camshaft section is sized to extend along three cylinders, and the first and second camshaft sections are connected in end-to-end relation.

[0042] In another embodiment, the carrier housing includes a plurality of bores for receiving fasteners to secure the carrier housing to the engine block. In yet another embodiment, the engine block is configured for an in-line engine cylinder arrangement. In one refinement, the number of cylinders is at least six.

[0043] In another embodiment, the engine block is configured for a V-shaped engine cylinder arrangement. In yet another embodiment, the camshaft is a single piece, single overhead camshaft. In a further embodiment, the camshaft includes at least two camshafts positioned in a double overhead arrangement and each of the at least two camshafts is a single piece camshaft. In still another embodiment, the system is a cam-less valve train.

[0044] According to another aspect of the present disclosure, an overhead cam support system includes a carrier housing configured to extend around a cylinder head of an engine. The carrier housing includes a lower end supported on an engine block of the engine independently of the cylinder head. The carrier housing includes at least one cam support arm extending over the cylinder head that rotatably supports at least one camshaft on the engine block.

[0045] In one embodiment, the system includes a camshaft retaining cap engaged to the cam support arm and the camshaft retaining cap extends around the at least one camshaft. In another embodiment, the carrier housing includes a plurality of first legs and a plurality of second legs on opposite sides of the cylinder head. The plurality of first and second legs each define a bore for receiving a fastener to secure the carrier housing to the engine block. In yet another embodiment, the carrier housing includes a flange extending over an upper surface of the cylinder head, and a seal is provided between the flange and an upper surface of the cylinder head.

[0046] In another aspect of the present disclosure, an overhead cam support system includes a lower carrier housing section and an upper carrier housing section mounted on the lower carrier housing section. The lower carrier housing section includes a plurality of legs with lower ends supported on an engine block along opposite sides of a cylinder head of an engine independently of the cylinder head. The lower carrier housing further includes flanges extending between and connecting adjacent pairs of the plurality of legs. The upper carrier housing section includes opposite sidewalls and opposite endwalls connecting the opposite sidewalls. The opposite endwalls are configured to rotatably support at least one camshaft along the cylinder head.

[0047] In one embodiment, at least a portion of the plurality of legs include a bore for receiving a fastener to secure the lower carrier housing section to the engine block. In another embodiment, the upper carrier housing section includes at least one cam support arm extending from one of the opposite sidewalls over the cylinder head and the camshaft is supported on the at least one cam support arm.

[0048] While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only certain exemplary embodiments have been shown and described and that all changes and modifications that come within the spirit of the inventions are desired to be protected. In reading the claims, it is intended that when words such as "a," "an," "at least one," or "at least one portion" are used there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. When the language "at least a portion" and/or "a portion" is used the item can include a portion and/or the entire item unless specifically stated to the contrary.

What is claimed is:

1. An overhead cam support system, comprising:

a carrier housing including a lower end positionable on an engine block independently of a cylinder head of the engine, the carrier housing rotatably supporting at least one camshaft on the engine block for engagement with at least one valve of the cylinder head.

2. The overhead cam support system of claim **1**, further comprising a valve cover engaged to an upper end of the carrier housing that is opposite the lower end of the carrier housing.

3. The overhead cam support system of claim **2**, wherein the carrier housing includes a flange extending over an upper surface of the cylinder head, and further comprising a seal between the flange and an upper surface of the cylinder head.

4. The overhead cam support system of claim **2**, wherein the carrier housing includes at least one cam support arm extending outwardly therefrom adjacent the upper end of the carrier housing, and the camshaft is supported on the at least one cam support arm.

5. The overhead cam support system of claim **4**, further comprising a camshaft retaining cap engaged to the cam support arm and the camshaft retaining cap extends around the at least one camshaft.

6. The overhead cam support system of claim **1**, wherein the at least one camshaft includes first and second camshafts including respective ones of first and second cam gears or phasers that are engaged to an idler gear mounted to the carrier housing.

7. The overhead cam support system of claim **1**, wherein the carrier housing includes first legs and second legs extending on opposite sides of the cylinder head and a first flange and a second flange extending along opposite sides of the cylinder head connecting the first legs and the second legs, respectively.

8. The overhead cam support system of claim **1**, wherein the engine block includes at least eight cylinders and each cylinder head extends over two cylinders.

9. The overhead cam support system of claim **1**, wherein the at least one camshaft includes at least two camshaft sections connected to one another in an end-to-end manner.

10. The overhead cam support system of claim **9**, further comprising a camshaft coupling that includes a center hub with splined sections extending axially in opposite directions from the center hub, and each camshaft section includes a longitudinal bore configured to receive respective ones of the splined sections.

11. The overhead cam support system of claim **10**, wherein each splined section includes a key projecting radially outwardly therefrom that is received in a keyway along the longitudinal bore of the respective cam section.

12. The overhead cam support system of claim **10**, wherein each splined section includes a non-circular cross-section that is received in a complementary shaped one of the longitudinal bores.

13. The overhead cam support system of claim **9**, wherein a first camshaft section is sized to extend along three cylinder pairs and a second camshaft section is sized to extend along two cylinder pairs, and the first and second camshaft sections are connected in end-to-end relation.

14. The overhead cam support system of claim **9**, wherein a first camshaft section is sized to extend along two cylinder pairs and a second camshaft section is sized to extend along two cylinder pairs, and the first and second camshaft sections are connected in end-to-end relation.

15. The overhead cam support system of claim **9**, wherein a first camshaft section is sized to extend along two cylinder pairs and a second camshaft section is sized to extend along one cylinder pair, and the first and second camshaft sections are connected in end-to-end relation.

16. The overhead cam support system of claim **9**, wherein a first camshaft section is sized to extend along three cylinders and a second camshaft section is sized to extend along three cylinders, and the first and second camshaft sections are connected in end-to-end relation.

17. The overhead cam support system of claim **1**, wherein the carrier housing includes a plurality of bores for receiving fasteners to secure the carrier housing to the engine block.

18. The overhead cam support system of claim **1**, wherein the engine block is configured for an in-line engine cylinder arrangement,

19. The overhead cam support system of claim **18**, wherein the number of cylinders is at least six.

20. The overhead cam support system of claim **1**, wherein the engine block is configured for an V-shaped engine cylinder arrangement.

21. The overhead cam support system of claim **1**, wherein the camshaft is a single piece, single overhead camshaft.

22. The overhead cam support system of claim **1**, wherein the camshaft includes at least two camshafts positioned in a double overhead arrangement and each of the at least two camshafts is a single piece camshaft.

23. The overhead cam support system of claim **1**, further comprising a cam-less valve train.

24. An overhead cam support system, comprising:

a carrier housing configured to extend around a cylinder head of an engine, the carrier housing including a lower end supported on an engine block of the engine independently of the cylinder head, the carrier housing including at least one cam support arm extending over the cylinder head that rotatably supports at least one camshaft on the engine block.

25. The overhead cam support system of claim **24**, further comprising a camshaft retaining cap engaged to the cam support arm and the camshaft retaining cap extends around the at least one camshaft.

26. The overhead cam support system of claim **24**, wherein the carrier housing includes a plurality of first legs and a plurality of second legs on opposite sides of the cylinder head, wherein the plurality of first and second legs each define a bore for receiving a fastener to secure the carrier housing to the engine block.

27. The overhead cam support system of claim **24**, wherein the carrier housing includes a flange extending over an upper surface of the cylinder head, and further comprising a seal between the flange and an upper surface of the cylinder head.

28. An overhead cam support system, comprising:

a lower carrier housing section that includes a plurality of legs with lower ends supported on an engine block along opposite sides of a cylinder head of an engine independently of the cylinder head, the lower carrier housing further comprising flanges extending between and connecting adjacent pairs of the plurality of legs; and

an upper carrier housing section mounted on the lower carrier housing section, the upper carrier housing section including opposite sidewalls and opposite endwalls connecting the opposite sidewalls, wherein the opposite endwalls are configured to rotatably support at least one camshaft along the cylinder head.

29. The overhead cam support system of claim **28**, wherein at least a portion of the plurality of legs include a bore for receiving a fastener to secure the lower carrier housing section to the engine block.

30. The overhead cam support system of claim **28**, wherein the upper carrier housing section includes at least one cam support arm extending from one of the opposite sidewalls over the cylinder head and the camshaft is supported on the at least one cam support arm.

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